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15 December 1980
GEE:cg

FROM: G. E. Ellis

TO: Naval Ocean Research and
Development Activity
Department of the Navy
NSTL Station, Mississippi 39529
Attn: Dr. R. Gardner, Code 520

SUBJECT: Final Report under Contract N00014-75-C-0429, Summary of Environmental Acoustic Measurements, Modeling and Analysis. (TL-EV-80-17).

Applied Research Laboratories, The University of Texas at Austin (ARL:UT), performed work under Contract N00014-75-C-0429 during the period 12 January 1974 - 30 September 1977. Areas of work included exercise and experiment planning, modeling, data processing, data analysis, and technical support. These tasks supported various LRAPP sponsored at-sea exercises planned and conducted during this performance period. This final report is divided into sections summarizing the tasks performed relative to each work area.

Final rep't. 12 Jan. 74-30 Sep 77

EXERCISE PLANNING

Planning included experiment design within an at-sea exercise, data processing and analysis planning, and total exercise design.

Bottom Interaction Experiment

ARL:UT designed and documented an integrated set of experiments to examine the influence of the ocean bottom on low frequency acoustic

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propagation. The experiments were based on the demonstrated ability to resolve and analyze the multipath effects measured using impulsive sources (SUS). The documentation for the exercise describes the experiment goals, design, site selection, experiment implementation, and the data reduction and analysis. This experiment planning represents the successful close interaction between acoustic modelers utilizing the appropriate tools, data processors, and at-sea operation engineers and scientists.

INDIAN OCEAN Preassessment

This exercise preassessment consisted of acoustic model selection, data evaluation, site selection, and the planning for production modeling. ARL:UT participated in all phases of the project through meetings, environmental data acquisition and assessment, and analysis of the production modeling. ARL:UT provided support to the AESD technical staff for the propagation and noise modeling and evaluation. Results and recommendations of this work were presented at the final INDIAN OCEAN preassessment meeting.

CHURCH STROKE II Exercise

ARL:UT assisted the Chief Scientist for the CHURCH STROKE II Cruise V in the planning for the measurements using the ACODAC and PAR midwater systems. Design was provided for the bottom interaction, propagation effects, ambient noise, and sensor performance experiments.

DATA PROCESSING

ARL:UT provided data assessments, quick look, and detailed data processing in support of at-sea exercises. These data were collected via the ACODAC midwater measurement systems.

Systems Upgrades

Upgrades were made to both the hardware and software associated

with the cw, ambient noise, and SUS processing systems. These modifications include a percentile estimator, improved cw line tracker, and enhanced playback electronics. The automation and accuracy of the systems were enhanced, while allowing for efficient narrowband processing of the appropriate data. Using ACODAC recorded tapes with a reference signal on each data channel, a repeatibility of 0.01 dB was achieved with a processing bandwidth of 0.01 Hz.

WESTLANT 74 Exercises

For the WESTLANT 74 Exercises, ARL:UT provided data assessment and processing from ACODAC systems. The cw data were processed for propagation loss and signal-to-noise and the ambient noise data were processed in narrowband spectra versus time. These results were provided to the Chief Scientist for reporting. Numerous model calculations using the PE model were performed and provided to the Chief Scientist.

CHURCH OPAL Exercise

ARL:UT participated in the data reduction and analysis planning, data assessment and processing, and the interpretation of the environmental acoustic measurements resulting from this exercise. Depth and frequency characteristics of the ambient noise field were determined from the ACODAC recorded data. Components contributing to the noise field were identified and quantified. Merchant ship signatures were processed and catalogued along with the measured propagation effects.

ACOUSTIC MODELING

During this contract period, several propagation models were acquired and implemented on the ARL:UT computer. These models provided the tools used in the acoustic modeling tasks performed.

SHARPS III

Three tasks were completed for SHARPS III. Sample data sets were developed for use in testing the modeling package. The sound

velocity profile curve-fitting routine used in the NISSIM model (to be used in SHARPS III) was investigated to determine when and where additional information is required to avoid excessive curvature in the fitted profile. A study was completed to determine the range-time interval selection to optimize the space-time domain standard eigenrays and the resolution in that domain.

MINIFACT

ARL:UT provided a modified version of the propagation model FACT for use as the propagation module in the TASSRAP ON-BOARD system. The task included implementation of the software for the specified NOVA 800 computer system and providing the accompanying documentation.

Wave Theory Modeling

Under this task, a study was conducted to evaluate the usefulness of the Langer technique for normal mode calculations. The motivation for this was the possibility of fast normal mode propagation calculations on small computers by avoiding lengthy numerical computations. The Langer solution is formally similar to the WKB solution, but since it is based on representation of mode functions by Airy functions, it is better suited to low frequency ocean acoustics modeling. This work consisted of analysis of the accuracy of eigenvalues and mode functions determined by the Langer method and of computational difficulties of the method. Example calculations were made at 50 Hz for an environment typical of the northeast Pacific Ocean.

The result of the study of eigenvalue and eigenfunction accuracy was as follows. The normal modes obtained are effectively identical to those from exact numerical calculations. The wave numbers (eigenvalues) are within 10^{-6} of the exact values. What this means is that the Langer technique is certainly useful for some applications: propagation in shallow water or deep water problems for ranges of a few hundred

kilometers or less. Because of the eigenvalue errors, coherent solutions in deep water will be degraded at longer ranges. However, the Langer solution would be useful for incoherent calculations at any range.

During this work, it was noted that a modified Langer approach would yield improved accuracy. This approach would do exact numerical solutions of differential equations which the Langer solution approximates. However, these differential equations have solutions which are better behaved than the basic depth equation for normal modes. That is, they are monotonic rather than oscillating. Hence, numerical solution would require much less computer time.

In a research situation with large computers available and numerical software for normal mode calculations there is no strong motivation for development of a general purpose Langer solution program. However, for shipboard calculations of normal modes, the Langer technique should be considered because of its small computer size requirement and quick execution time.

ANALYSIS AND INTERPRETATION

During this contract period, ARL:UT's role was broadened from data assessment and processing to the analysis and interpretation of the environmental acoustic measurements.

Signal Travel Time

Additional work was completed on the successful measurement and modeling of signal travel time using impulsive (SUS) sources. ACODAC recorded data from the CHURCH ANCHOR exercise were used.

Ambient Noise

Additional data from the CHURCH OPAL and CHURCH ANCHOR exercises were processed and integrated with previous results to provide a better

description of the deep water ambient noise fields and the contributing components. These results describe the frequency, depth, and wind dependencies of the field.

Bottom Interaction Assessment

ARL:UT performed a feasibility study for extracting the bottom interaction effects on propagation using ACODAC data recorded during previous LRAPP sponsored exercises. The multipath analysis technique was successfully used on data recorded during the SQUARE DEAL exercise, demonstrating that useful bottom interaction information can be extracted from "pre-analyzed" exercise data.

Ship Signatures

Merchant ship signatures of opportunity recorded during the CHURCH OPAL exercise have been analyzed and the results documented in a technical report. A "best estimate" of source level was attempted using these data.

TECHNICAL SUPPORT

ARL:UT provided technical support to both LRAPP and NORDA Code 32 during this contract period. This support consisted of technical briefings and consultations relative to the measurement, modeling, and data analysis aspects of the program. ARL:UT staff participated as members of site visit teams and technical advisory groups, and in proposal evaluation.

KENT BEACON Exercise

ARL:UT processed data recorded via the LAMBDA towed array in an attempt to diagnose the difficulties experienced with the shipboard recording system operated during the exercise. Two types of beamformers were implemented in software on the CDC 3200 computer. The results of this task were provided to NOSC.

cw Diagnostic Plan

ARL:UT together with Dr. M. Weinstein (USI) and Dr. J. Hanna (SAI) formulated a cw diagnostic plan to determine the uniformity of cw data processing by LRAPP participants. The plan was forwarded to the LRAPP Manager in a technical memorandum.

Environmental Acoustic Summary Reports

ARL:UT participated in the preparation of the SQUARE DEAL and CHURCH OPAL Environmental Acoustic Summary Reports.

PAR Evaluation

ARL:UT participated in the monitoring effort of LRAPP on the PAR development and fabrication. Calibration and recording procedures were developed to support efficient and accurate data reduction. ARL:UT conducted this technical analysis and evaluation of the laboratory characterization tapes and the at-sea wet test.

Tape Duplication Facility

ARL:UT participated in the Magnetic Tape Advisory Group concerned with the evaluation and planning of a LRAPP sponsored analog magnetic tape duplication facility for ACODAC and PAR systems.

FDDT Data Processing

The on-board software routines used for the FDDT processing of LAMBDA data were implemented on an in-house HP 2100 minicomputer. Data processing was provided to support the post-exercise acoustic

assessment for CHURCH STROKE I and II Exercises. Software modifications were implemented and provided to the at-sea technical team for Cruise IV.

G.E. Ellis
Assistant Director

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1. In accordance with reference (a), a declassification review has been conducted on a number of classified LRAPP documents.

2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

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Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
Unavailable	Unavailable	SELF-TENSIONING ACOUSTICAL HORIZONTAL LINE ARRAY (SPRAY) DATA ANALYSIS. FINAL REPORT OF BEARING STAKE TESTS JANUARY THRU MARCH 1977. VOLUME IVB. DATA POINTS 10, 11 AND 12 RAW DATA	Sanders Associates, Inc.	790109	ADC017579	U
ARLTR7924	Mitchell, S. K., et al.	ANALYSIS OF ACOUSTIC BOTTOM INTERACTION IN BEARING STAKE (U)	University of Texas, Applied Research Laboratories	790223	ADE001369; NS; ND	U
TIU1886502F	Eichenberger, D.	REPORT FOR CHURCH STROKE II OCEANOGRAPHIC SERVICES	Texas Instruments, Inc.	790326	ADB036751; ND	U
Unavailable	Unavailable	FINAL REPORT, 1 NOVEMBER 1976-31 DECEMBER 1978	Xonics, Inc.	790430	ADB037987	U
Unavailable	Mitchell, T. M.	PREMOBILIZATION OF R/V INDIAN SEAL	Texas Instruments, Inc.	790531	ADB039703	U
Unavailable	Hays, E. E.	ACODAC AMBIENT NOISE PROGRAM	Woods Hole Oceanographic Institution	790601	ADB040404	U
LRAPPR79029	Unavailable	INTRODUCTION TO THE LRAPP ENVIRONMENTAL-ACOUSTIC DATA BANK (U)	Naval Ocean R&D Activity	790601	ADB041066; NS	U
USRD NO. 4807	Unavailable	MEASUREMENTS ON AQUADYNE MODEL AQ-1 ELEMENTS FOR THE UPGRADED LAMBDA ARRAY	Naval Research Laboratory	790802	ND	U
Unavailable	Ellis, G. E.	SUMMARY OF ENVIRONMENTAL ACOUSTIC DATA ANALYSIS	University of Texas, Applied Research Laboratories	790814	ADA073876	U
BR U0048-9C2	Unavailable	TAP III FINAL REPORT (U)	Bunker-Ramo Corp. Electronic Systems Division	790901	ND	U
ORITR1245	Moses, E. J.	OPTIONS, REQUIREMENTS, AND RECOMMENDATIONS FOR AN LRAPP ACOUSTIC ARRAY PERFORMANCE MODEL (U)	ORI, Inc.	790917	NS; ND	U
Uavailable	Colborn, J. G., et al.	EVALUATION OF STANDARD OCEAN CANDIDATES	Pacific-Sierra Research Corp,	800301	ADA087304	U
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